DoD Internet Protocol Static Routing

Internal Design Specification

December 18, 1985

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TDRB APPROVAL: _____

AD&C APPROVAL: _____

CONTROL DATA CORPORATION

DOCUMENT CONTROL FORM

o DOCUMENT TYPE: IDS

o LOG ID: ARH7141

o TITLE: DOD Internet Protocol Static Routing IDS

o ABSTRACT: This document describes the internal design of the CDCNET implementation of static routing for DOD's Internet Protocol

o PRODUCT AFFECTED: CDCNET, DCNS

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o MAIL STATION: ARH207 o EXTENSION: x3367

o PROJECT: ACSD Development

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o SIP Number(s)

o PUB #

o PRM #

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NUMBER	DATE	TYPE	SUBMITTED BY	DEFAULT APPROVAL DATE	CURRENT STATUS: REVIEW	HOLD	APPROVED	WITHDRAWN
1	1/9/86	Orig	J. R. Lyman	NONE			A	

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4901H - 0145H/0146H

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RECORD OF REVISION

Revision	Description	Author	Date
01	Draft Version	JRL3	11/21/85
02	Revised for TDRB comments	JRL3	12/18/85

1.0 INTRODUCTION

This document describes the internal design of the DoD Internet Protocol Static Routing (IPSR) module. The IPSR module contains the routing tables that are used by all other DoD protocols. Routines are provided to maintain the table of directly connected hosts and the table of reachable networks. Command processors are provided to maintain both of these tables. The major purpose of this module is fulfilled by a routine provided to determine the next hop for a given datagram.

The IPSR routines run under the task of the caller. The module is basicly a set of routines that hide the routing table. The routines which require memory allocation will return appropiate error messages.

2.0 REFERENCES

The following manuals contain material that either defines the operations of the TCP module and the modules it interfaces to, or provides additional insight into the use of the TCP module.

[1]	RFC-791	SRI	DoD Internet Protocol
[2]	RFC-792	SRI	DoD Internet Control Message Protocol
[3]	MIL-STD-1777	DoD	DoD Internet Protocol Standard
[4]	ARH6265	CDC	DoD Internet Protocol ERS
[5]	ARH7118	CDC	Dod IP Static Routing ERS
[6]	ARH7016	CDC	DoD Internet Protocol IDS

3.0 ENVIRONMENT

3.0 ENVIRONMENT

3.1 HARDWARE

The IPSR module has no special hardware requirements. The IPSR module is part of the CDCNET software and will run on a 68000 based Device Interface (DI). The module will be written in the CYBIL language, and will be compiled and bound using SES tools on a CYBER mainframe.

3.2 SOFTWARE

The IPSR module depends on a number of other software components in order to function in the DI. The following sections list these components and itemize the services of each component that the IPSR module uses.

3.2.1 INTERNET PROTOCOL MODULE

The IP module provides an indication for each ICMP redirect datagram that it receives. This interface allows an IPSR module in a host which contains no other routing protocol to keep its network table dynamically updated.

3.2.2 3A INTRANET MODULE

The 3A Intranet module provides a basic point-to-point data transfer service between two systems connected to a common network solution. The IPSR module will open a SAP with the 3A module in order to receive status information about the IP networks that the 3A module supports. The IPSR module will expect to receive the following information from the 3A module for each such IP network

1. The IP address of the network connection.

2. The 3A System ID.

3. The 3A network ID.

4. The maximum packet size.

5. And the current status of the network.

3.2.3 STATUS COMMAND PROCESSOR

The IPSR module will provide a report procedure that the status command processor can call to display the contents of the routing tables.

3.2.4 EXECUTIVE COMMON ROUTINES

The IPSR module will use a number of the common subroutines that are provided as part of the executive. The following services with be expected from the executive routines.

1. Buffer management.

2. Memory allocation.

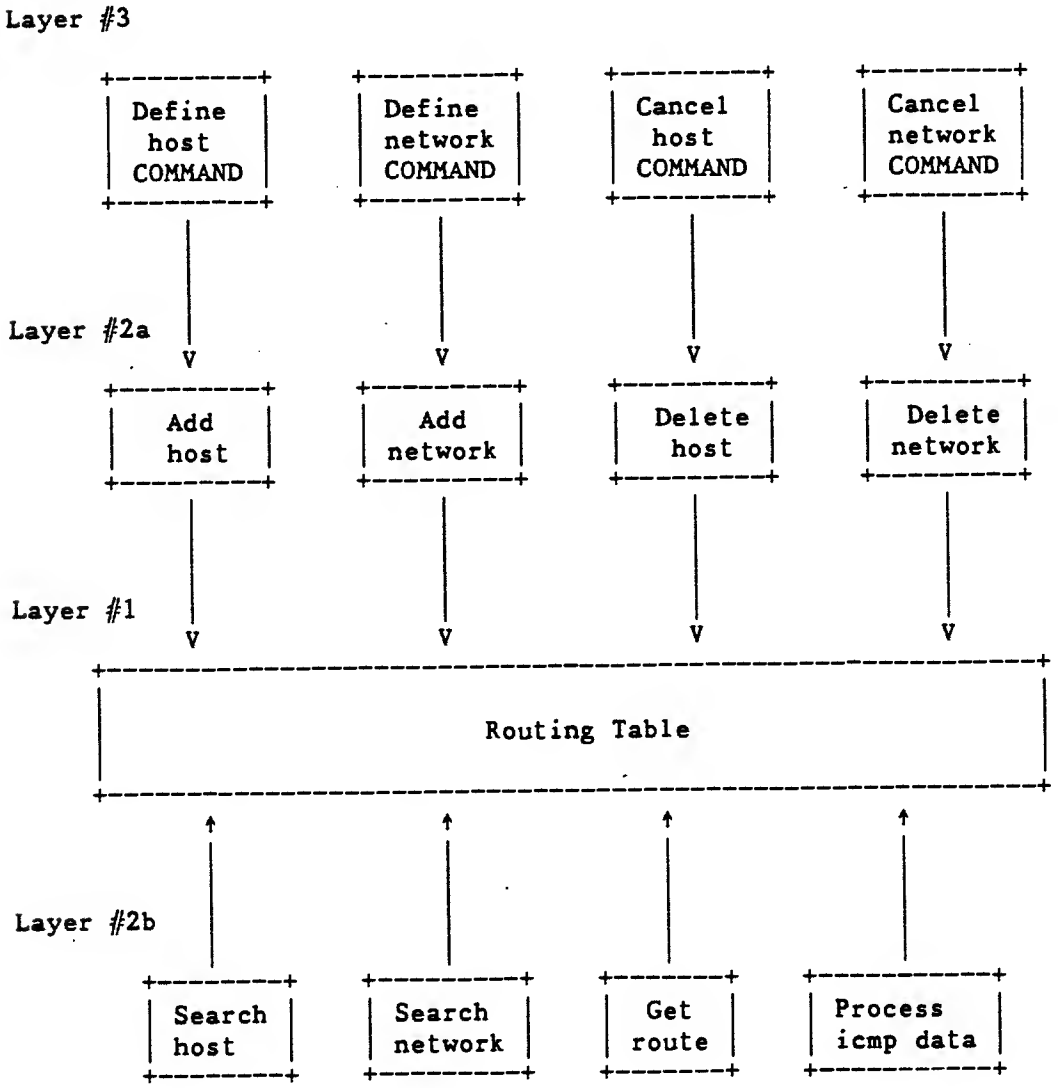
3. Memory deallocation.

4. Binary Tree Table Management.

5. Timer management.

4.0 DESIGN OVERVIEW

The IPSR module is composed of three layers of software. The following diagram illustrates the components of each layer, and the relationships between the layers.



4.0 DESIGN OVERVIEW

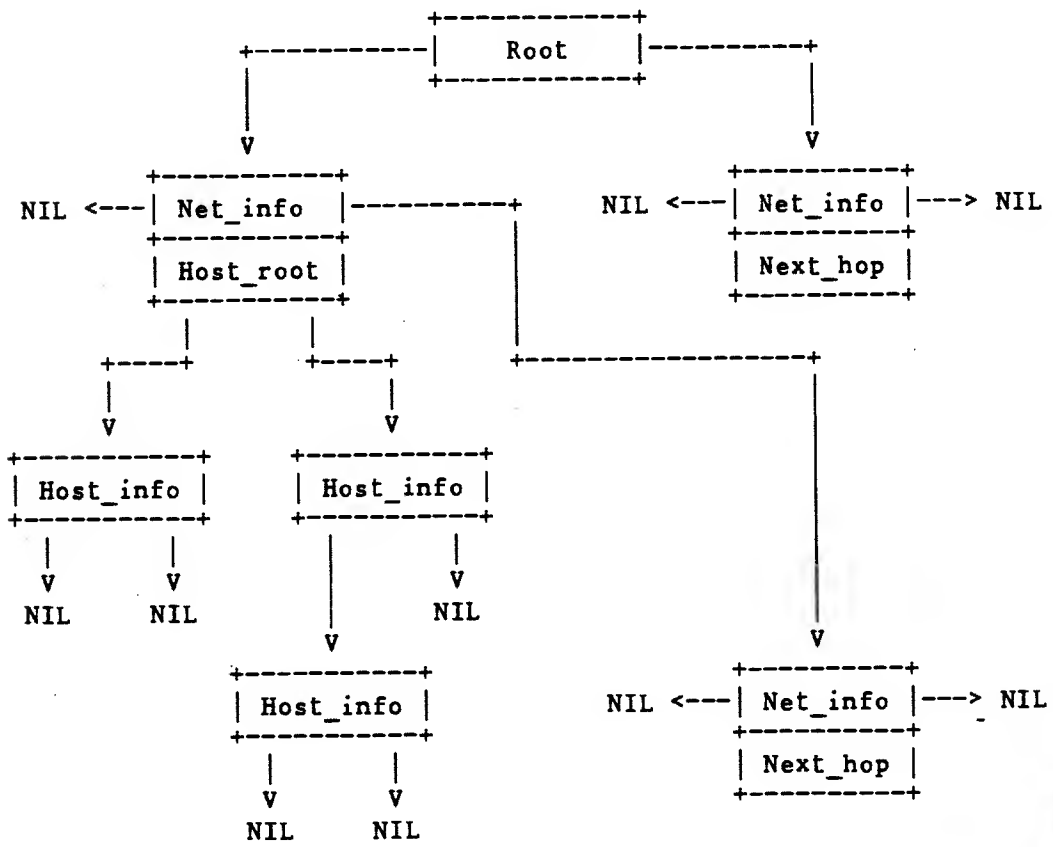
The first layer is composed of the routing table itself. This table will contain all information necessary to determine the next stop in a datagrams route. The table will be sorted so that the time needed to determine that next stop will be minimized. In fact, the time needed to modify the table will be considered unimportant. It is assumed that a Gateway Protocol module will contain tables which it will use in addition to the routing table.

The second layer contains the routines that maintain the routing table. These routines allow the host/network table to be updated directly and are used to process ICMP datagrams. This layer also contains the routine which IP calls to determine the next stop for a given datagram. All of these routines are intimately familiar with the structure of the routing tables.

The final layer contains four command processors. These command processors are intended to allow the network operator to maintain the routing table manually. This will be necessary as long as there is no dynamic routing protocol (Gateway Protocol) available. These command processors will make calls to the layer two routines, they will therefore, do very little actual processing.

4.0 DESIGN OVERVIEW

The routing table is composed of a nested binary tree. The main tree contains a node for each network that the IPSR module knows about. Each network node will either be locally or remotely connected. The nodes for remotely connected networks will indicate the next hop to that network. The nodes for locally connected networks will contain a binary tree of all the hosts known to reside on that network. The following diagram specifies a possible structure of the table.



4.1 FUNCTIONAL STRUCTURE

4.1.1 SERVICE_ROUTINES

The routines described in this section are provided for the use of any module that needs to update the routing tables. The use of the routines in this section allows a user to restrict his knowledge of the internal structure of the routing tables to the format of an individual entry. The search routines allow the user to access a specific entry in a routing table without knowing how the entries are arranged in the table.

4.1.1.1 Add host

This routine is used to add the information about a directly connected host into the routing table. Each IP host on a directly connected IP network must be entered into the routing table with this routine. All hosts in a connected CDC Catenet to whom a gateway provides direct service, are considered to be directly connected to that gateway and must be entered into its routing tables with this routine. The format of the CYBIL interface is as follows:

Call format

```
PROCEDURE ipsr_add_host (
   host_address : ip_address;
   host_type    : ipsr_host_type;
   egp_active   : BOOLEAN;
   igp_active   : BOOLEAN;
   3a_network   : net_id_type;
   3a_system    : sys_id_type;
   VAR status   : ipsr_status_type);
```

host_address	In	This is the IP address of the host being defined.
host_type	In	This is the type of host being defined.

egp_active	In	This flag is set if an external gateway protocol is active in this host.
igp_active	In	This flag is set if an internal gateway protocol is active in this host.
3a_network	In	This is the 3A net_id of the network solution that the host is connected to.
3a_system	In	This is the 3A system_id of the host.
status	Out	This is the status of the request. The following values may be returned: ipsr_successful ipsr_host_exists ipsr_invalid_address ipsr_invalid_type ipsr_unknown_network ipsr_insufficient_resources

Global data accessed

1. The network/host table will be accessed, and may be updated.

General Algorithm

```
BEGIN
   IF (INVALID parameter) THEN
      RETURN(error_message);
   ELSE
      CALL ipsr_search_host_table (for the specified host);
      IF found THEN
         RETURN(ipsr_host_exists);
      ELSE
         Search for the network;
         IF (NOT found) OR (NOT directly connected) THEN
            RETURN(ipsr_unknown_network);
         ELSE
            Add the host to the networks host table;
            IF addition successful THEN
               RETURN(ipsr_successful);
            ELSE
               RETURN(ipsr_insufficient_resources);
            IFEND;
         IFEND;
      IFEND;
   IFEND;
END
```

4.1.1.2 Add network

This routine is used to add information about a reachable network into the routing table. This routine will be used at first by the command processor which adds networks. It may also be used by modules that provide dynamic routing services. The format of the CYBIL interface is as follows:

Call format

```
PROCEDURE ipsr_add_network (
   network    : 0..0FFFFFF(16);
   gateway    : ip_address;
   hop_count  : INTEGER;
   owner      : ipsr_net_owners;
   VAR status : ipsr_status_type);
```

network	In	This is the network number of the network that is being added to the routing table.
gateway	In	This is the IP address of the gateway that datagrams destined for this network should be sent to.
hop_count	In	This is the number of gateways that the datagrams must pass through to reach this network.
owner	In	This is the owner of the table entry. Dynamic routing modules may use this value to insure that they only delete entries that they added.
status	Out	This is the status of the request. The following values may be returned: ipsr_successful ipsr_invalid_owner ipsr_network_exists ipsr_unknown_gateway ipsr_insufficient_resources

Global data accessed

1. The network/host table will be accessed, and may be updated.

General Algorithm

```
BEGIN
   IF (owner INVALID) THEN
      RETURN(ipsr_invalid_owner);
   ELSE
      Search for the specified network;
      IF found THEN
         RETURN(ipsr_network_exists);
      ELSE
         CALL ipsr_search_host_table (for the gateway);
         IF NOT found THEN
            RETURN(ipsr_unknown_gateway);
         ELSE
            Add the network to the table;
            IF addition successful THEN
               RETURN(ipsr_successful);
            ELSE
               RETURN(ipsr_insufficient_resources);
            IFEND;
         IFEND;
      IFEND;
   IFEND;
END
```

4.1.1.3 Delete host

This routine is used to delete a host from the routing table. When an existing entry needs to be changed, the current entry must be deleted and then the new entry added. The format of the CYBIL interface is as follows:

Call format

```
PROCEDURE ipsr_delete_host (
   host_address : ip_address;
   VAR status   : ipsr_status_type);
```

host_address	In	This is the IP address of the host.
status	Out	This is the status of the request. The following values may be returned: ipsr_successful ipsr_unknown_host ipsr_invalid_address

Global data accessed

1. The network/host table will be accessed, and may be updated.

4.0 DESIGN OVERVIEW
4.1.1.3 Delete_host

General Algorithm

```
BEGIN
   IF (host_address INVALID) THEN
      RETURN(ipsr_invalid_address);
   ELSE
      CALL ipsr_search_host_table (for the specified host);
      IF NOT found THEN
         RETURN(ipsr_unknown_host);
      ELSE
         Delete the host entry;
         IF (host_type=ip_gw) OR (host_type=cdc_gw) THEN
            Update default gateway if needed;
            Change networks using this gateway to default;
         IFEND;
         RETURN(ipsr_successful);
      IFEND;
   IFEND;
END
```

4.1.1.4 Delete network

This routine is used to delete information about a reachable network from the routing table. This routine will be used at first by the command processor which removes networks. It may also be used by modules that provide dynamic routing services. The format of the CYBIL interface is as follows:

Call format

```
PROCEDURE ipsr_delete_network (
   network    : 0..0FFFFFF(16);
   owner      : ipsr_net_owners;
   VAR status : ipsr_status_type);
```

network	In	This is the network number of the network that is being removed from the routing table.
owner	In	This is the owner of the table entry. Dynamic routing modules may use this value to insure that they only delete entries that they added.
status	Out	This is the status of the request. The following values may be returned: ipsr_successful ipsr_invalid_owner ipsr_unknown_network

Global data accessed

1. The network/host table will be accessed, and may be updated.

General Algorithm

```
BEGIN
   IF (owner INVALID) THEN
      RETURN(ipsr_invalid_owner);
   ELSE
      Search for the specified network;
      IF NOT found THEN
         RETURN(ipsr_unknown_network);
      ELSE
         IF (network_type=direct) THEN
            Delete the host table;
         IFEND;
         Delete the network entry;
         RETURN(ipsr_successful);
      IFEND;
   IFEND;
END
```

4.1.1.5 Get route

This routine is called by the IP module when a datagram is received. The IPSR module uses the destination address, the source address, and the ip routing options to determine the best place for the datagram to go next. The source address is optional and the IPSR module will determine it and return it to the IP module if not specified. The 3A network_id and the 3A system_id of the local destination are returned to the IP module along with the type of destination. This routine will also process the IP routing options, if there are any, and updates them according to the IP protocol. The format of the CYBIL interface is as follows:

Call format

```
PROCEDURE ipsr_get_route (
      from_network   : BOOLEAN;
      header         : ip_header;
   VAR source        : ip_address;
      destination    : ip_address;
   VAR options       : ip_option_record;
   VAR host_info     : ipsr_host_rec;
   VAR max_data_size : INTEGER;
   VAR status        : ipsr_status_type);
```

from_network	In	This flag should be TRUE if the datagram that is being routed was received from a network.
header	In	This is the header of the IP datagram.
source	I/O	This is the IP address of the source, this should be the address of the DI on a directly connected network. This parameter is optional and will be chosen by the IPSR module if not specified.
destination	In	This is the destination of the IP datagram.

options	I/O	This is an array which contains the IP routing options.
host_info	Out	This is a record which contains the routing information that the IP module requires.
max_data_size	Out	This is the maximum number of bytes that a datagram being sent to the indicated destination can contain.
status	Out	This is the status of the request. The following values may be returned: ipsr_successful ipsr_unable_to_route ipsr_invalid_option

Host_type
net_ID
SYS_ID

Global data accessed

1. The network/host table will be searched.

4.0 DESIGN OVERVIEW
4.1.1.5 Get_route

General Algorithm

```
BEGIN
   IF parameter error THEN
      RETURN(appropriate message);
   ELSE
      Process the options in the header;
      IF routing options THEN
         Determine the next destination;
      IFEND;
      Search for the destination network;
      IF network found THEN
         IF network_type=direct THEN
            Search the network's host table;
            IF host not found THEN
               RETURN(ipsr_unable_to_route);
            IFEND
         ELSE
            Call ipsr_search_host_table(gateway);
            IF gateway not found THEN
               Log internal error;
               Use the default gateway;
            IFEND;
         IFEND;
         Copy info. from the network and host entries;
         IF source not specified THEN
            Find our local address on the dest. network;
            Record the local address as the source;
         IFEND;
         RETURN(ipsr_successful);
      ELSE
         IF NOT from_network THEN
            CALL ipsr_add_network(dest.net,default_gateway);
            Copy info. from the network and host entries;
            IF source not specified THEN
               Find our local address on the dest. network;
               Record the local address as the source;
            IFEND;
            RETURN(ipsr_successful);
         ELSE
            RETURN(ipsr_unable_to_route);
         IFEND;
      IFEND;
   IFEND;
END
```

4.1.1.6 Process icmp data

This routine is called by the IP module to indicate that it has received an ICMP datagram. This is the only dynamic routing information that a standard DoD host will receive. The format of the CYBIL interface is as follows:

Call format

```
PROCEDURE ipsr_process_icmp_data (
   error_type  : ipsr_icmp_ind;
   source      : ip_address;
   destination : ip_address;
   new_gateway : ip_address);
```

error_type	In	This is the type of ICMP datagram that is being reported.
source	In	This is the source address from the datagram that the ICMP datagram pertains to.
destination	In	This is the destination address from the datagram that the ICMP datagram pertains to.
new_gateway	In	This is the IP address of the gateway that the datagram should have been sent to.

Global data accessed

1. The network/host table will be updated.

4.0 DESIGN OVERVIEW
4.1.1.6 Process_icmp_data

General Algorithm

```
BEGIN
   Search for the specified network;
   IF network exists THEN
      CASE error_type OF
         =ipsr_end_source_quench=
            IF network.status=net_congested THEN
               network.status := net_up;
               network.timeouts := 0;
            IFEND;
         =ipsr_net_unreachable=
            network.hop_count := unreachable_hop;
            network.status := unknown;
         =ipsr_redirect=
            CALL ipsr_search_host_table(new_gateway);
            IF gateway found THEN
               network.hop_count := unknown_hop;
               network.timeouts := 0;
               next_hop := new_gateway_index;
            IFEND;
         =ipsr_source_quench=
            IF network.status=net_up THEN
               network.status := net_congested;
            IFEND;
         =ipsr_time_exceeded=
            IF (net.status=net_up) OR (net.status=unknown) THEN
               network.timeouts := network.timeouts + 1;
               IF network.timeouts>=timeout_threshold THEN
                  network.hop_count := unreachable_hop;
                  network.status := unknown;
               IFEND;
            IFEND;
      CASEND;
   IFEND;
END
```

4.1.1.7 Search host table

This routine will search the network/host table; the host_address will be used as the key. If an entry is found then a pointer to the host information record will be returned, else the pointer will be NIL.

Call format

```
PROCEDURE ipsr_search_host_table (
   host_address   : ip_address;
   VAR host_entry : ↑ipsr_host_info);
```

host_address	In	This is the address of the host that we are searching for.
host_entry	Out	This is a pointer to the information about the host if its found in the table. If the host is not found then this pointer is returned as NIL.

4.0 DESIGN OVERVIEW
4.1.1.7 Search_host_table

Global data accessed

1. The network/host table will be accessed.

General Algorithm

```
BEGIN
   Search for the specified network;
   IF (not found) OR  (network_type=remote) THEN
      host_entry := NIL
   ELSE
      Search the networks host table;
      IF not found THEN
         host_entry := NIL
      ELSE
         host_entry points to the host entry;
      IFEND;
   IFEND;
END
```

4.1.1.8 Search network table

This routine will search the network table. The network number will be used as the key. If an entry is found then a pointer to the network information record will be returned, else the pointer will be returned NIL.

Call format

```
PROCEDURE ipsr_search_network_table (
   network_number : 0..FFFFFF;
   VAR network_entry : ↑ipsr_network_info);
```

network_number	In	This is the network number of the network that we are searching for.
network_entry	Out	This is a pointer to the information record of the network being searched for, if the network is not found then the pointer will be returned NIL.

Global data accessed

1. The network/host table will be accessed.

4.0 DESIGN OVERVIEW
4.1.1.8 Search_network_table

General Algorithm

```
BEGIN
   Search for the specified network;
   IF the network is found THEN
      network_entry points to the networks entry;
   ELSE
      network_entry := NIL;
   IFEND;
END
```

4.1.2 COMMAND_PROCESSORS

The IPSR module provides four command processors. These commands allow the network operator to manually update the routing tables. In the initial releases these commands will be the only way to keep the routing tables up to date. In later releases, after dynamic routing capability is added, they will hopefully be needed very little.

4.1.2.1 Define ipsr host

This routine is called by the Command ME command processor interface task to process the Define_IPSR_host command. This command allows the network operator to add a host/gateway to the routing tables. For a definition of the procedure parameters, see the Command ME ERS.

Call format

```
PROCEDURE cmd_define_ipsr_host (
   parameter_list : ost$string;
   VAR pvt        : clt$parameter_value_table;
   VAR c_code     : condition_code;
   VAR status     : clt$status);
```

Global data accessed

1. The IPSR routine table will be updated.

4.0 DESIGN OVERVIEW
4.1.2.1 Define_ipsr_host

General Algorithm

```
BEGIN
   Process the parameters;
   IF all parameters valid THEN
      CALL ipsr_add_host;
      RETURN(appropriate message);
   ELSE
      RETURN(error message);
   IFEND;
END
```

4.1.2.2 Define ipsr network

This routine is called by the Command ME command processor interface task to process the Define_IPSR_network command. This command allows the network operator to add a reachable network to the routing tables. For a definition of the procedure parameters, see the Command ME ERS.

Call format

```
PROCEDURE cmd_define_ipsr_network (
   parameter_list : ost$string;
   VAR pvt        : clt$parameter_value_table;
   VAR c_code     : condition_code;
   VAR status     : clt$status);
```

Global data accessed

1. The IPSR routine table will be updated.

General Algorithm

```
BEGIN
   Process the parameters;
   IF all parameters valid THEN
      CALL ipsr_add_network;
      RETURN(appropriate message);
   ELSE
      RETURN(error message);
   IFEND;
END
```

4.1.2.3 Cancel ipsr host

This routine is called by the Command ME command processor interface task to process the Cancel_IPSR_host command. This command allows the network operator to delete a host/gateway from the routing tables. For a definition of the procedure parameters, see the Command ME ERS.

Call format

```
PROCEDURE cmd_cancel_ipsr_host (
   parameter_list : ost$string;
   VAR pvt        : clt$parameter_value_table;
   VAR c_code     : condition_code;
   VAR status     : clt$status);
```

Global data accessed

1. The IPSR routing table will be updated.

General Algorithm

```
BEGIN
   Process the parameters;
   IF all parameters valid THEN
      CALL ipsr_delete_host;
      RETURN(appropriate message);
   ELSE
      RETURN(error message);
   IFEND;
END
```

4.1.2.4 Cancel ipsr network

This routine is called by the Command ME command processor interface task to process the Cancel_IPSR_network command. This command allows the network operator to delete a network from the routing tables. For a definition of the procedure parameters, see the Command ME ERS.

Call format

```
PROCEDURE cmd_cancel_ipsr_network (
   parameter_list : ost$string;
   VAR pvt        : clt$parameter_value_table;
   VAR c_code     : condition_code;
   VAR status     : clt$status);
```

Global data accessed

1. The IPSR routing table will be updated.

General Algorithm

```
BEGIN
   Process the parameters;
   IF all parameters valid THEN
      CALL ipsr_delete_network;
      RETURN(appropriate message);
   ELSE
      RETURN(error message);
   IFEND;
END
```

4.1.2.5 Process status command

The IPSR module allows the network operator to examine the contents of the various routing tables. The command processor provided is described in this section. For a definition of the parameters, see the Command ME ERS.

Call format

```
PROCEDURE cmd_display_ipsr_table_status (
   parameter_list : ost$string;
   VAR pvt        : clt$parameter_value_table;
   VAR c_code     : condition_code;
   VAR status     : clt$status);
```

Global data accessed

1. All of the routing tables will be accessed.

General Algorithm

```
BEGIN
   Process the parameters;
   IF all parameters valid THEN
      Get the routing table address;
      Build the response buffer;
   IFEND;
END
```

4.1.3 INTERNAL_ROUTINES

The routines described in this section are internal to the IPSR module and are not provided to the user. This small set of routines will be called by other routines in the IPSR module.

4.1.3.1 Process 3a data

The address of this routine is provided to the 3A module to allow the presentation of data indications. However, the IPSR module should never receive any data from 3A. The routine will therefore discard any data that it should happen to receive and a log message will be generated.

Call format

```
PROCEDURE process_3a_data (
   multicast     : BOOLEAN;
   receive_netid : net_id_type;
   sending_sysid : sys_id_type;
   VAR datagram  : buf_ptr);
```

multicast	In	This flag will be TRUE if the datagram was sent as a broadcast datagram.
receive_netid	In	This is the network identifier of the network solution that the datagram was received on.
sending_sysid	In	This the system identifier of the system that transmitted the datagram.
datagram	In	This is a pointer to the system buffer which contains the datagram.

4.0 DESIGN OVERVIEW
4.1.3.1 Process_3a_data

Global data accessed

1. None.

General Algorithm

```
BEGIN
   Release the system buffer;
   Log as an internal error;
END
```

4.1.3.2 Process 3a status

The address of this routine will be provided to the 3A module for the presentation of status indications. The status indications will be used by the IPSR module to keep the routing tables up to date as much as possible.

Call format

```
PROCEDURE receive_3a_status (
   nib_ptr : nib_type);
```

nib_ptr	In	This is a pointer to the information block of the network whose status has changed.

Global data accessed

1. The network/host table will be updated.

General Algorithm

```
BEGIN
   Search for the specified network;
   IF the network is found THEN
      Update the status;
   ELSE
      CALL ipsr_add_network;
   IFEND;
END
```

4.2 DATA STRUCTURES

4.2.1 CONSTANTS AND TYPES

The IPSR module uses a number of ordinals. The status returned by its routines is an ordinal, and there are other identifiers that are defined as ordinals. The CYBIL definition of the various ordinals follows.

```
CONST
   unreachable_hop = -1,

   timeout_threshold = 10,

   ipsr_net_unreachable = 20,
   ipsr_source_quench = icmp_source_quench,
   ipsr_redirect = icmp_redirect,
   ipsr_time_exceeded = icmp_time_exceeded;


TYPE
   ipsr_status_type = (
      ipsr_successful,          { Function completed.
      ipsr_host_exists,         { The host is in the list.
      ipsr_insufficient_resources,  { Memory alloc. error.
      ipsr_invalid_address,     { Illegal host address.
      ipsr_invalid_owner,       { Owner parameter incorrect.
      ipsr_invalid_type,        { Illegal host type.
      ipsr_network_exists,      { Network already exists.
      ipsr_unable_to_route,     { No route is available.
      ipsr_unknown_gateway,     { Gateway not in the list.
      ipsr_unknown_host,        { No such host in the list.
      ipsr_unknown_network),    { No such net in the list.

   ipsr_host_type = (
      ip_host,          { IP host on an IP network.
      cdc_host,         { CDC host in a CDC Catenet.
      ip_gw,            { IP gateway on an IP network.
      cdc_gw,           { IP gateway in a CDC catenet.
      local,            { IP address of this gateway.
      none),
```

4.0 DESIGN OVERVIEW
4.2.1 CONSTANTS AND TYPES

```
ipsr_icmp_ind = (
   ipsr_net_unreachable, ipsr_source_quench,
   ipsr_redirect,        ipsr_time_exceeded);

ipsr_net_owners = (
   all,             { Everyone owns this entry.
   ipsr,            { The routing module owns it.
   egp,             { The External Gateway owns it.
   igp),            { The Internal Gateway owns it.

ipsr_connect_status = (
   unknown,         { The status is unknown.
   available,       { Status up and available.
   unavailable,     { Status up but unavailable.
   down),           { Status down.

ipsr_network_type = (
   direct,          { Directly connected.
   remote);         { Connected thru a gateway.
```

4.2.2 NETWORK/HOST TABLE

The information kept by the routing module includes networks and hosts/gateways. The structure used is a nested binary table. The first level table is keyed by network number. Each entry describes a known network. IF the network is directly connected then there will be a field which points to a second level table which contains all of the hosts/gateways that reside on the network; the host number being used as the key.

CYBIL data definitions

```
TYPE
   ipsr_network_info = RECORD
      status : ipsr_connect_status,
      CASE net_type : ipsr_network_type OF
         =direct=
            local_address : ip_address,
            max_data_size : INTEGER,
            3a_network    : net_id_type,
            3a_system     : sys_id_type,
            host_root     : root,
         =remote=
            next_hop  : ip_address,
            hop_count : INTEGER,
            owner     : ipsr_net_owners,
            timeouts  : INTEGER,
      CASEND,
   RECEND,

   ipsr_host_info = RECORD
      host_type  : ipsr_host_type,
      egp_active : BOOLEAN,
      igp_active : BOOLEAN,
      3a_system  : sys_id_type,
      status     : ipsr_connect_status,
   RECEND;


VAR
   default_gateway    : ip_address,
   ipsr_routing_table : root;
```

Data Field Descriptions

default_gateway — This is the index of the gateway that datagrams are sent to when they are not being forwarded and the destination network is not contained in the network table.

egp_active — This flag is set TRUE if the addressed host supports the DoD External Gateway Protocol.

hop_count — This is the number of gateways that a datagram will pass through to reach a remote network.

host_type — This is the type of host.

host_root — This is a pointer to a directly connected networks host table.

igp_active — This flag is set TRUE if the addressed host supports an Internal Gateway Protocol.

ipsr_routing_table — This is the root of the routing table.

local_address — This is the IP address of the host/gateway.

max_data_size — This is the maximum size for a datagram that is sent out on a particular network.

next_hop — This is the IP address of the gateway that data for a remote network should be sent to.

owner — This is the owner of a specific network entry.

status — This is the status of a specific network or host.

timeouts — This is the number of timeout indications that have been received for datagrams sent to a remote network through a particular gateway.

3a_network — This is the 3A network id of the directly connected IP network.

3a_system	This is the 3A system id of a host on a directly connected network.

Creation/Modification

1. The network/host table will be initialized as empty.
2. The six service routines will update the table.

4.3 INITIALIZATION

The IPSR module does not run as a separate task. The data structures that are used by the IPSR module must be allocated dynamically and SAPs must be opened with the 3A module and the Status module. In order to perform initialization, a flag will be kept to indicate if initialization has been completed. Each routine called from outside the module will check the flag and perform initialization if the flag is not set. So the first call to the IPSR module will force initialization.

4.4 DESIGN CRITERIA AND ALTERNATIVES

The design of the IPSR module is very important to all users of the IP module due to the fact that each datagram processed by the IP module will require a call to the IPSR module. The following performance goals have been recognized in the design.

1. Since the routing routine must be called for each datagram, all data tables are designed to optimize the searches needed to determine a route.

2. Because routing table updates are off-line from datagram traffic, the work done by these functions is considered to have low priority.

The general design of the IPSR module is affected by the following functional goals.

1. No set of input values should cause the IPSR module to abort in an uncontrolled manner.

2. Access to the routing tables by outside code should be controlled as much as possible.